International Journal of Computer Science Engineering
and Information Technology Research (IJCSEITR)
ISSN(P): 2249-6831; ISSN(E): 2249-7943
Vol. 6, Issue 3, Jun 2016, 11-18

TRANS STELLAR
•Journal Publications •Research Consultancy

STUDY OF DIFFERENT TRANSFORMATION ALGORITHMS IN DIGITAL IMAGE WATERMARKING

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ABSTRACT

There is a big issue related to security on the growth of Internet. This is the era of digital data that is transferred on Internet when data is transferred on the Internet there is a problem of authentication and security to the data. Digital data is in the form of audio, video, images etc. Digital image watermarking is used to hide the data with the cover image for authentication. Many techniques have been proposed for robust, secured, high embedding capacity in the world of digital image watermarking such as DCT, DWT, SVD, Fourier Transformation This paper presents overall techniques that have been used in image watermarking and also we presents the combination of the method such as singular value decomposition (SVD), discrete cosine transformation (DCT), discrete wavelet transformation(DWT), Fourier Transformation. The keynote for image watermarking is PSNR and NC values .PSNR is used to calculate the image quality factor and NC used to measure the robustness of image . Digital image watermarking is done in two ways i.e. block based and frequency based or sometimes we used a hybrid method.

KEYWORDS: Digital Image Watermarking, Singular Value Decomposition (SVD), Discrete Cosine Transform (DCT), Discrete Wavelet Transformation (DWT).

Received: Apr 02, 2016; **Accepted:** Apr 20, 2016; **Published:** Apr 22, 2016; **Paper Id.:** IJCSEITRJUN201602

Original Article

INTRODUCTION

By doing watermarking we provide evidence of authenticity, basically a simple watermark is a form, image or text that is impressed onto the paper. A Watermarking is adding an “ownership” information in multimedia contents to prove the authenticity. Whereas Digital watermarking is an extension of a simple watermark and it is related to the digital world. There is a need for mechanisms to protect ownership of digital media in the digital world in recently growing field of Internet. In recent years there is a big problem related to copies of digital information, be it images, text or audio, can be produced and distributed easily. So we face the problem with our content in the digital world and we are not aware for authentication of the data. Digital image watermarking is one solution that provides authentication to the legal user. It basically attaches the some authentic data to the original data(cover image). Watermarking is of two types : i) invisible and ii) visible data. Here we are concerned about invisible watermarking in image processing field. An image is represented by pixels and also done in the form of frequency. When watermarking is done on pixels values that is called block based watermarking or spatial, in this type of watermarking least significant bit (LSB) is used for performing transformation and in frequency based watermarking we done through high and low pass filters when data is in the form of frequency there is two type of techniques that is used in watermarking DCT and DWT. Frequency based watermarking is more robust than spatial based watermarking.

There is basically two-phase of digital image watermarking that is embedding and extraction.

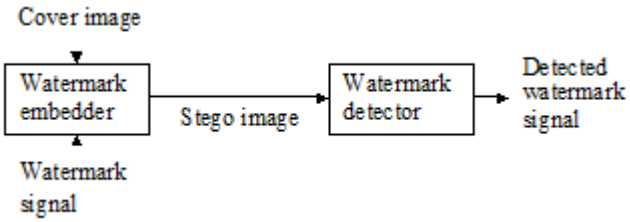

Figure 1

Characteristics of Watermarking

Some of the characteristics of watermarking are listed as follows:

- **Robustness:** It is of three types that are fragile, semi-fragile, and robust. If the slightest modification is done in watermarked image and it fails called as fragile. If it resists after some changes then it is semi-fragile. A watermarked image is called robust if it resists all the designated class of transformation.
- **Perceptibility:** If original cover signal and the marked signal are perceptually indistinguishable then it is called imperceptibility. If the marked signal is perceptible with the naked eye in a cover image then it is called perceptibility.
- **Embedding Method:** There are three types for embedding the watermark image in cover image **: i)** spread spectrum **ii)** quantization **iii)** amplitude modulation

Transformation Techniques

Transformation techniques can be divided on the basis of spatial domain and frequency domain.

In spatial domain, we learn about singular value decomposition (SVD), and frequency domain methods are discrete cosine transformation (DCT) discrete sine transformation (DST) discrete Fourier transformation (DFT) discrete wavelet transformation (DWT).

- **LSB (least significant bit)**

Information can be inserted directly into every bit of image information or we can calculate more busy areas of an image because it is less perceptible parts of an image, these areas could be used for hiding such messages. These methods were based on the pixel value's Least Significant Bit (LSB) modifications. The algorithm proposed by Kurah and McHughes [9] to embed in the LSB and it was known as image downgrading [2]. Let us understand the mechanism of the less predictable or less perceptible of Least Significant Bit insertion algorithm.

In a grayscale image, each pixel is represented by 1-byte consist of 8 bits. And total combination in gray scale is 256 in which 0 is for black and for white 255. The principle of encoding uses the Least Significant Bit of each of these bytes, the bit on the far right side. If data is encoded to only the last two significant bits (which are the first and second LSB) of each color component it is most likely not going to be detectable; the human retina becomes the limiting factor in viewing pictures [7].

For the sake of this example, only the least significant bit of each pixel will be used for embedding information. If the pixel value is 138 which is the value 10000110 in binary and the watermark bit is 1, the value of the pixel will be 10000111 in binary which is 139 in decimal. This is a very simple method used for watermarking embedding procedure.

- **Singular Value Decomposition (SVD):**

SVD is one efficient numerical analysis tool used for analyzing matrices. In this, a matrix is decomposed into three matrices. Given a rectangular matrix of dimension n×n, this matrix can be transformed into U,D and V components respectively. $A = U\ D\ V^T$ U and V are orthogonal matrices and D is diagonal matrix with non-negative entries satisfy such that:

$d_{1,1} \geq d_{2,2} \geq d_{3,3} \geq \ldots\ldots \geq d_{r,r} > d_{r+1,r+1} = \ldots = d_{n,n} = 0.$

X' is the reconstructed matrix obtained by the inverse SVD transformation.

The relation between X and three matrix U,V and D satisfies $XV_i = D_iU_i$ and $U_i^TX = D_iV_i^T$.

- **Discrete Cosine Transformation (DCT)**

It represents an image as a sum of sinusoidal of varying magnitudes and frequencies. It is also known as DCT1, DCT2 in which frequency is represented in one-dimensional and two-dimensional. DCT is related to DFT. It also transforms a time domain signal into its frequency components however only it uses the real parts of the DFT coefficients. DCT has a strong energy compaction property and most of the signal information tends to be concentrated in a few low-frequency components. DCT is been used in JPEG standard for image compression due to its performance. DCT could be applied in many fields such as data compression, pattern recognition, image-processing, and so on. The DCT-2 transformation can be expressed as follows:

$$XC_{pq} = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} XN_{mn}.\frac{c(p)c(q)}{4}.\cos\left(\frac{\pi(2m+1)p}{2M}\right).\cos\left(\frac{\pi(2n+1)q}{2N}\right)$$

First, the 1D DCT of the rows are calculated and then the 1D DCT of the columns are calculated. The 1D DCT coefficients for the rows and columns can be calculated by separating equation1 into the row part and the column part.

$$C = K \bullet \cos\frac{(2 \cdot col\#+1) \bullet row\# \bullet \pi}{2 \bullet M}$$, where K = √1/N for row = 0, √2/N for row ≠ 0

$$C^t = K \bullet \cos\frac{(2 \cdot row\#+1) \bullet col\# \bullet \pi}{2 \bullet N}$$, where K = √1/M for col = 0, √2/M for col ≠ 0

M = total no. of columns, N = total no.of rows

- **Discrete Wavelet Transformation (DWT)**

DCT is an extension of Fourier transform. But as we know Fourier coefficient contains complete information about the behavior of the series at one frequency but no information about its behavior at other frequencies because DCT is not a multi-resolution in behavior so researcher develops various multi-resolution representation of functions. Multi-resolution represent our signal in terms of functions that are localized both in time and frequency. Wavelet use low and high pass filters in which we obtain sub-band, that is low-level and high-level sub-bands. In low-level sub-band, we get less information and high-level sub-band contains detailed information. We have 1D DWT,2D DWT. In 1D DWT

information is represented only horizontally. But 2D DWT information is represented by both horizontally and vertically. The DWT (Discrete Wavelet Transform) separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH). The dwt-based watermarking scheme is the most robust to noise addition than DCT. For 2-D images, DWT has applied 2-D filters in each dimension that means horizontally and vertically . The filters divide the input image into four non-overlapping multi-resolution sub-bands LL, LH, HL, and HH. The LL sub-band represents the coarse-scale DWT coefficients while the LH, HL, and HH sub-bands represent the fine-scale DWT coefficients. To obtain the next coarser scale of wavelet coefficients, the LL sub-band is further processed until some final scale N is reached.

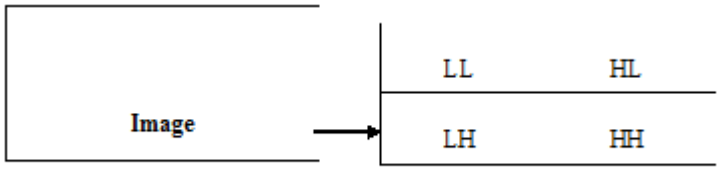

Figure 2

LITERATURE REVIEW

Chang [2005] et al. proposed **"**SVD-based digital image watermarking scheme"[1]. In their study, they proposed a new image watermarking scheme based on SVD was proposed. SVD transformation is quite different from the commonly used DCT, DFT, and DWT transformations. Since non-fixed orthogonal bases and one-way non-symmetrical decomposition are employed in SVD. These properties provide the advantages of various sizes of transformation and more security.

Li [2007] et al. proposed "Adaptive DWT-SVD Domain Image Watermarking Using Human Visual Model"[2]. In this paper, it is proposed that a hybrid DWT-SVD domain watermarking scheme considering human visual properties. After decomposing the host image into four sub-bands, we apply SVD to each sub-band and embed singular values of the watermark into them.

Veysel Aslantas [2008] proposed "A singular-value decomposition-based image watermarking using genetic algorithm"[3]. In this paper author proposed a novel optimal watermarking scheme based on singular-value decomposition (SVD) using genetic algorithm (GA) is presented. Modifications are optimized using GA to obtain the highest possible robustness without losing the transparency.

Singh [2014] et al. proposed "A Chaotic Map Based DCT-SVD Watermarking Scheme For Rightful Ownership Verification"[4]. In their work a hybrid watermarking scheme integrating the concepts of the singular value decomposition and discrete Cosine transform has been presented in the paper. The security is enhanced by the usage of chaotic Map as the only rightful owner having the secret keys can retrieve the hidden information.

Li [2014] et al. proposed "A DCT-SVD Domain Watermarking for Color Digital Image Based on Compressed Sensing Theory and Chaos Theory"[5]. In this paper, author proposed a new color image watermarking algorithm is proposed that is based on CS theory and chaos theory in DCT domain and SVD domain. The experiment results prove the scheme is feasible and reliable. Moreover, the usage of the chaos scrambling and SVD is to ensure the security and good anti-attack ability for JPEG compression, Gaussian white noise, median filtering and rotating.

Mali [2014] et al. proposed "Comparative Performance Analysis of Digital Image Watermarking Scheme in DWT and DWT-FWHT-SVD Domains"[6]. In this paper author proposed robustness, high embedding capacity and strong security in digital image watermarking techniques is challenging issue. The proposed method here fulfills these requirements simultaneously. The proposed DWT-FWHT-SVD based method is strongly robust to 19 various noise additions and filtering attacks.

Wang [2014] et al. proposed "A Geometrically Resilient Robust Image Watermarking Scheme Using Deformable Multi-Scale Transform"[7]. In this paper, they have developed a geometrically resilient robust image watermarking scheme by designing the DMST that has joint shift ability in position, orientation, and scale.

Furqan [2014] et al. proposed "Study and Analysis of Robust DWT-SVD Domain Based Digital Image Watermarking Technique Using MATLAB" [8]. In this paper author proposed a robust and blind digital image watermarking technique to achieve copyright protection. In their paper, they implement that algorithm of digital watermarking by combining both DWT and SVD techniques. Initially, they decompose the original (cover) image into 4 sub-bands using 2-D DWT, and then we apply the SVD on each band by modifying their singular values.

Hawlader [2014] et al. proposed "SVD based robust and secure dual stages watermarking scheme for copyright protection" [9]. In this paper, a robust and secure dual stages digital image watermarking scheme is proposed for copyright protection in SVD domain. In order to provide high security, the proposed scheme used Logistic map to encrypt the primary watermark and Arnold's cat map to scramble the cover image.

Sharma [2015] et al. proposed "Robust digital watermarking for colored images using SVD and DWT technique" [10].]. In this paper author proposed watermarking is the technique to solve the issue of copyright degradation, but this has to be resolved by keeping a steady check on the imperceptibility and robustness which incur to be its main objectives. The idea behind using a hybrid transform is that the cover image is modified in its singular values rather than on the DWT sub-bands, therefore the watermark makes itself vulnerable to vivid attacks.

Kaur [2015] et al. proposed "Robust Digital Image Watermarking in High Frequency Band Using Median Filter Function Based on DWT-SVD" [11]. This paper proposed a new robust digital image watermarking technique to protect the data. Digital watermarking technique is proposed using median filter function based on discrete wavelet transform and singular value decomposition. Original image is passed through median filter function to make the image smooth, then first level wavelet transform is applied.

Shah [2015] et al. proposed "A DWT-SVD based digital watermarking technique for copyright protection" [12]. In this paper, they proposed SVD-based digital watermarking technique for robust watermarking of digital images for copyright protection. The security of the proposed scheme is increased by applying another wavelet function. They also demonstrate the good correlation between the embedded and the extracted watermark with the help of experimental results.

Raval [2015] et al. proposed "Secure and robust watermarking technique" [13]. In this paper, authors propose a novel watermarking approach based on DWT and SVD to satisfy all the three constraints. In this approach watermark is customized using singular values (SV) computed on DWT sub-band of cover image. Unlike other algorithms, watermark is not inserted into SV's of DWT sub-band. While doing singular value decomposition on cover image, SV's of watermark replaces the SV's of the DWT sub-band. Signatures of orthogonal matrices associated with SV's of watermark are then computed and inserted into third level LL and HH band of cover image.

APPLICATIONS

A wide range of applications of digital image watermarking has been broadly and successfully deployed in billions of media objects. The following application areas in which digital watermarking may be used for a wide range of applications:

- Usage-Specific Requirements
- Copyright Protection
  - Misappropriation by other content providers
  - Illicit use of end users
- Annotation Watermarking
- Fingerprinting
- Automatic Playlist Generation for Rights Verification
- Multimedia Authentication
- Watermarking for Copy Protection

CONCLUSIONS

A key concern in Digital Image Watermarking is to increase the PSNR for imperceptibility and NCC for robustness of Image. Since the year 1990, there has been much research in the field of image processing for authentication of data. Least Significant Bit(LSB) probably the first method that has been used for data tampering in the form of pixel value but today it is not used due to its simplicity. The quality of image decreases using LSB in watermarking. After that SVD approach has been used for watermarking it increase the quality factor of embedded image but not resist attacks. Now DCT and SVD approach is been used for many attacks as well as for quality factor. Latest trends use DWT- SVD for better robustness and a high-quality factor of the images DWT is been used at many levels such as 2 level DWT and 3 level DWT. Now in recent years, authors propose a combination of spatial and frequency-based domain and also research is been progressing for multiple watermarking on the original image and also we can focus on a combination of DCT DWT SVD approach.

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